An attempt to convert multi-traits into Quality index for describing durum wheat quality

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ABSTRACT

Quality is an important feature for all the stakeholders in wheat value chain including breeders, farmers, millers, food processors, and consumers. Nevertheless, wheat quality is a multidimensional concept based on multiple attributes that define wheat end-use characteristics. These attributes include physical factors such as kernel size, vitreousness and kernel density, compositional factors like protein content and gluten strength, and even visual aspect as yellow index. Moreover, these quality traits might have favorable and unfavorable associations and could be strongly influenced by environment making quality evaluation very complex. Selection of elite wheat genotypes would be easy if a single system of quality assessment is considered.

In this context, the present study aims an attempt to convert the multivariate wheat quality evaluation into a single system called wheat quality index. This study involved five pertinent durum wheat quality traits: Vitreousness, test weight, thousands kernel weight, protein content and yellow color, recorded for twenty-eight varieties in fifteen environments of Morocco. The computation of the overall quality index is based on the summation of individual quality index * weighting factors for the trait where each quality index is based either on original or normalized values of the trait. Weights assigned to each attribute reflects trait importance in determining end use quality as indicated by processors. Quality index assessment using the two approaches allows the ranking of genotypes according to the national quality standards into four major categories based on a scale from 0 to 5.

Statistical analysis of data showed significant effects of environment for all quality parameters. Some traits exhibited high values in humid environments (like test weight), while others showed high values in drier areas (like protein content and vitreousness). Furthermore, the correlations between some quality traits were revealed but remained moderate showing the complexity of multi-traits selection and the need of a single quality index. Global quality index for durum wheat varieties in fifteen environment based on transformed and non-transformed data ranged respectively from 0.46 to 5.00 and from 62.66 to 133.24%. The principal component analysis (PCA) explained 94.45% of the overall variability and revealed that the outputs of the two calculated quality index are in line with the selection based on the performance of each genotype for each trait according to standards.

Materials and Methods

- ✓ Twenty-eight durum wheat varieties were evaluated in fifteen environments of Morocco; Environments were defined as combinations of four seasons and seven locations covering the major agro-ecological zones of Morocco. Five pertinent durum wheat quality traits: Vitreousness (VIT), test weight (PS), thousands kernel weight (PMG), protein content (TP) and yellow color (b) were recorded in each environment.

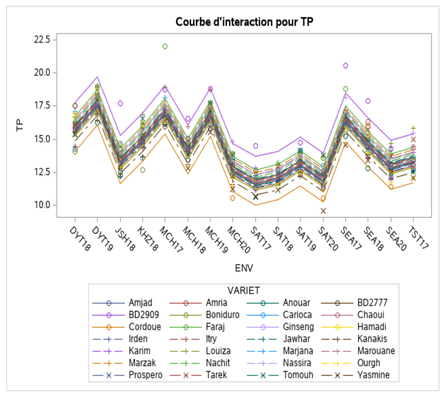
- ✓ A single system called quality index was computed using two approaches based on transformed and non transformed data. The transformation of the trait value is based on normalizing data into 0 to 5 scale depending on the Moroccan norms. These values are multiplied by the weighting factors for each trait. Weights assigned to each attribute were reflecting trait importance in determining end use quality as indicated by processors. The computation of the overall quality index is based on the summation of individual quality index. $QI_{Genotype} = \sum_{i=1}^{n} X_i W_i$ where, xi is the transformed/non transformed value of ith wheat quality indicator variable and Wi is the weight of the ith variable.

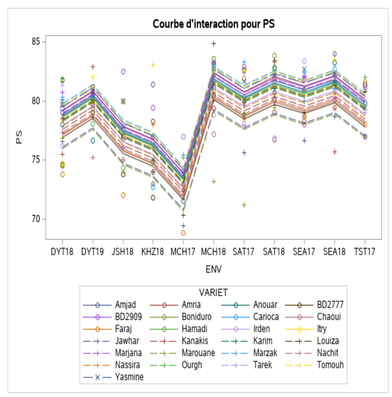
- ✓ Quality index assessment using the two approaches allows the ranking of genotypes according to national quality standards into four major categories based on a scale from 0 to 5; very high (5), high (3), moderate (1) and low (0). Combined analysis of variance (ANOVA) using SAS Software version 9.0 was conducted to assess genotype, environment and genotype by environment interaction effects on quality traits. Pearson correlation analysis was carried out to assess relationships between parameters. PCA was carried out to analyze the relation between quality indexes.

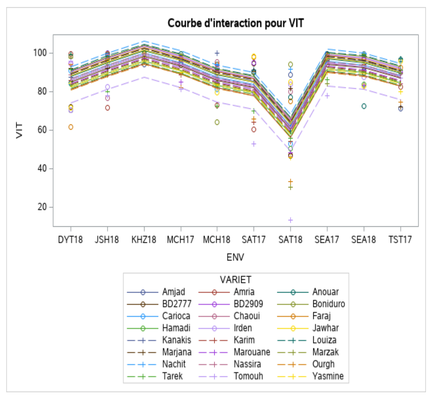
Results and Discussion

- ❑ The analysis of variance showed large environmental and genetic effect ($P<0.001$) for all quality parameters (Sisson et al., 2020).

- ❑ An environment cannot show high-level performances for all quality traits (Mohan et al, 2021). The genetic potential for some traits is better exhibited in some environments than others (Graphs). Protein content (TP) is higher in dry areas (17%) compared to humid environments (11%), while test weight values (PS) are higher in favorable zones (83 kg/hl) compared to dry ones (74 kg/hl). Vitreousness (VIT) presented lower values in sub-humid environments (60%) compared to drier areas (100%).





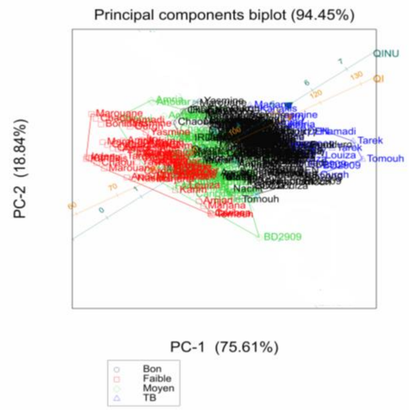


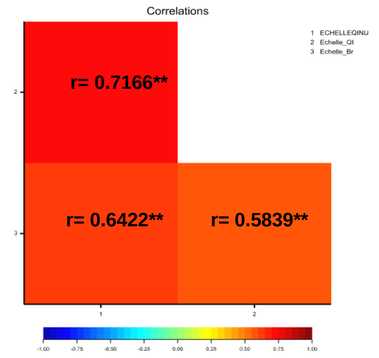
- ❑ Some quality traits showed significant correlations. Positive and significant correlations between protein content and vitreousness ($r=0.44$; $p<.0001$) and yellow color ($r=0.44$; $p<.0001$) were recorded, while this trait exhibited significant and negative correlations with test weight ($r=-0.24$; $p<0.0002$). Yet, these correlations were moderate, which showed the complexity of the multi-traits selection (Taghouti et al., 2019) and the need of a single quality index.

- ❑ Global quality index for durum wheat varieties in fifteen environment based on transformed and non-transformed data ranged respectively from 0.46 to 5.00 and from 62.66 to 133.24%. Each single quality index computed was able to differentiate between the different genotypes based on their quality performances ($P<0.001$).

- ❑ The PCA explained 95% of the total variability and demonstrated the similarity between the two quality indexes calculated (Figure 1). Therefore, both approaches can be used interchangeably.

- ❑ The genetic selection based on the two approaches was compared to the breeder selection. Results showed positive and significant correlation between the two qualities indexes and breeder selection ($r= 0.6422$; $p<.0001$) (Figure 2)





Conclusion & Recommendations

- ❑ The high environmental and genetic effect on the multi-quality traits for durum wheat and the moderate correlation between these quality features required by industrials and consumers support the need of a single quality index for an efficient selection of the best genotypes.

- ❑ This system might provide a framework for the development of tools for overall quality evaluation required in the upstream (in breeding) and the downstream (quality control for industrials) of wheat chain value. Further analysis are required to assess and validate these two quality indexes using different genetic backgrounds.

References

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